



High Efficiency Variable Speed Versatile Power Air Conditioning System

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GVSETS

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- Improved Energy Efficiency
- Improved reliability
- Power versatility, can run from AC and DC sources
- Cooling load adaptive, variable Speed
- Fully operable up to 140 degrees Fahrenheit

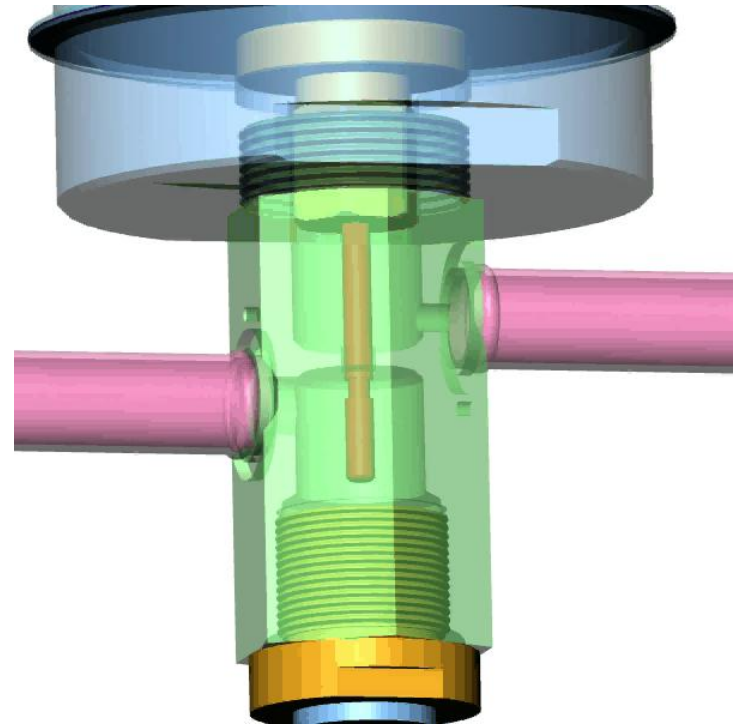


- Pulsing Refrigerant Flow Control Air Conditioners
 - Advanced Refrigerant Flow Control
 - Advanced Refrigerant Distribution with Enhanced Heat Transfer
 - Enhanced Reliability, Energy Saving
- Variable Frequency Drive Air Conditioners
 - VSD Compressor Optimization with use of Pulsing TXV
 - AC/DC Power Management Design, DC-BUS
 - Weight, Volume and Energy Savings; Lower Noise

Advanced Pulsing Thermal Expansion Valve (PTXV)

POWER AND MOBILITY

- Rocky Research Innovation
- No small orifices and no plugging problems.
- Pulsing operation allows precise superheat control over a wide range of refrigerant flow rates.
- Pressure sensing determines pulsation frequency, thus ensuring precise superheat control.
- Fully mechanical, no electronics are required.

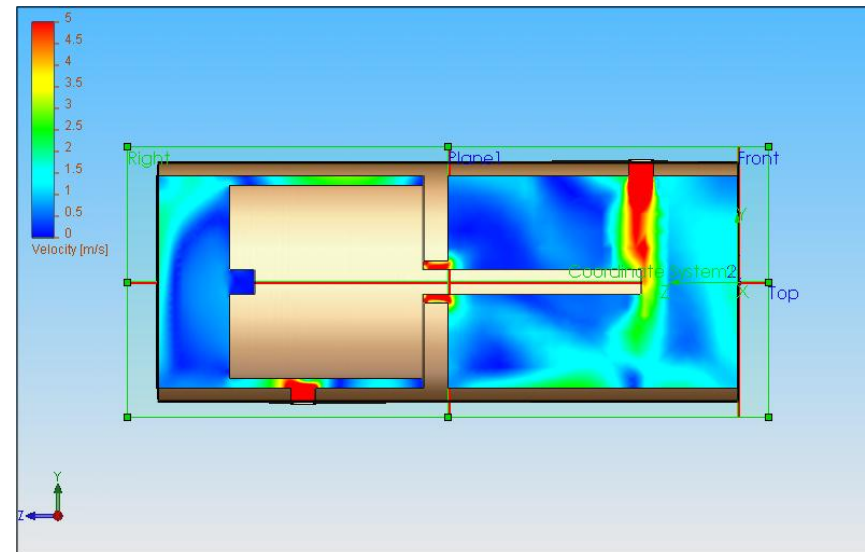
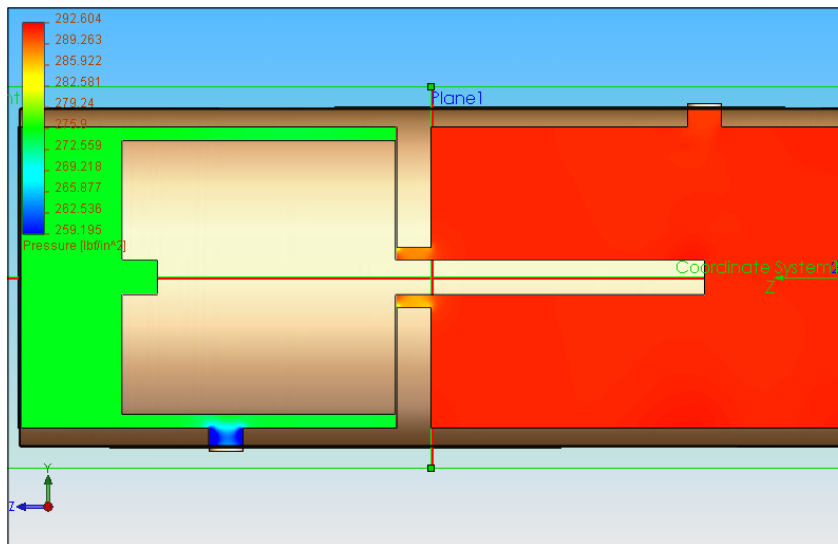


U.S. Patent No 5,675,982 and 6,843,064

PTXV CFD Analysis

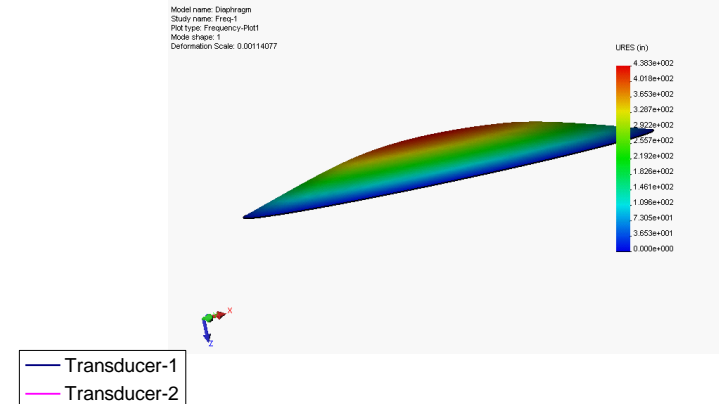
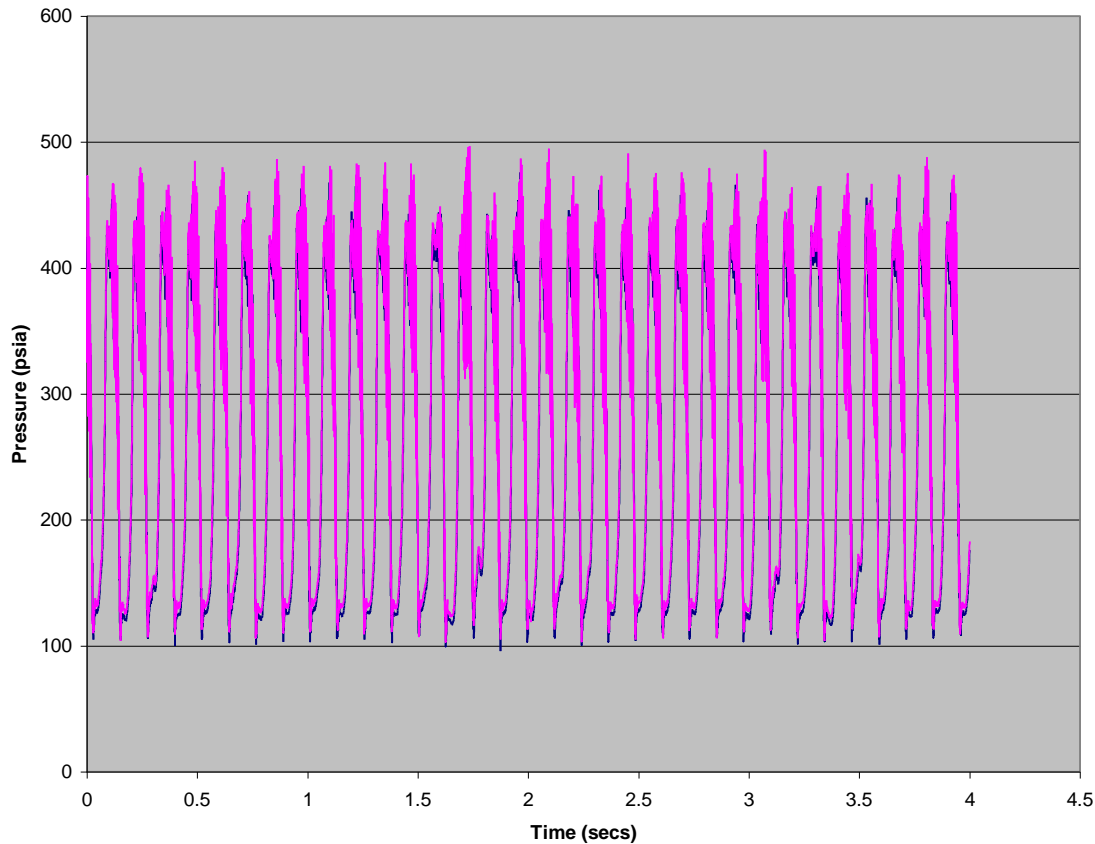
POWER AND MOBILITY

- Optimized geometry
- Design concept applicable for wide range of HVAC and refrigeration systems
- One TXV size can be used for a wide range of cooling capacity



Pressure Pulsation Measurement

POWER AND MOBILITY



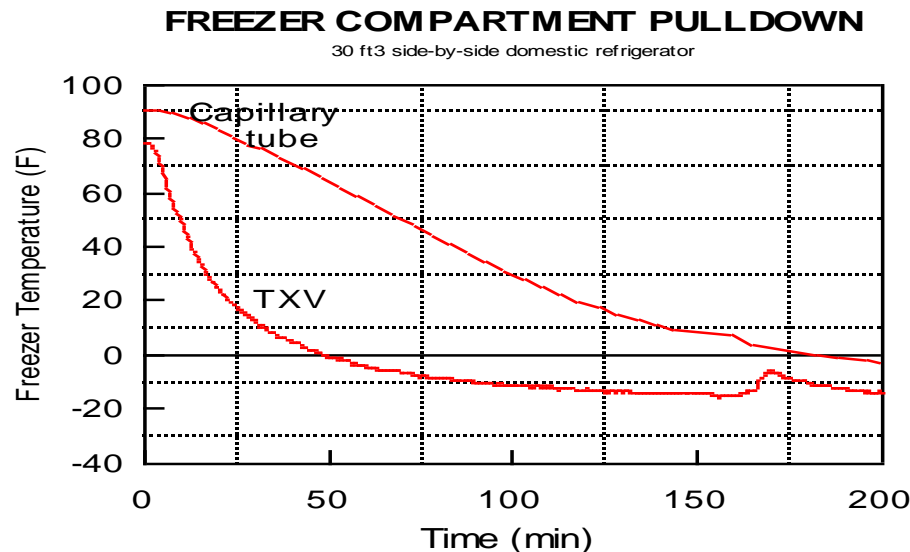
Advantages

**POWER AND
MOBILITY**

- Improved energy efficiency
- Improved cooling capacity
- Faster pull-down or compressor size reduction for the same pull-down
- Facilitates and/or optimizes use of multiple/variable speed compressors

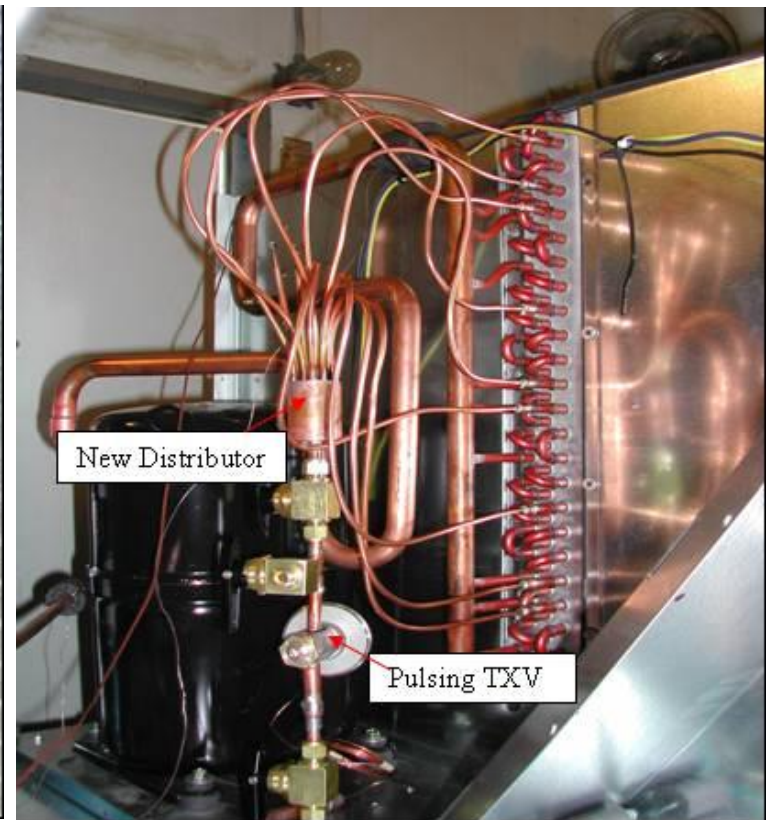
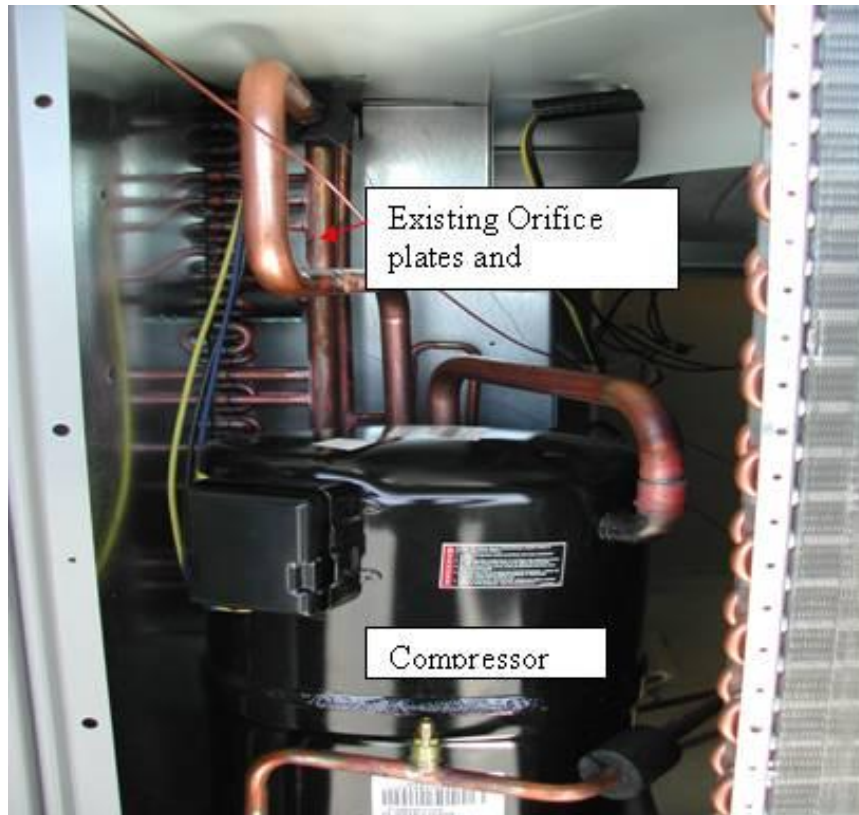
Side-by-Side Refrigerator

- 30 cubic-foot side-by-side domestic unit
- 350% pull down improvements over a capillary
- TXV suitable for use in high volume manufacturing



Test of Carrier 5 ton, R22, 50TM006 model

POWER AND MOBILITY





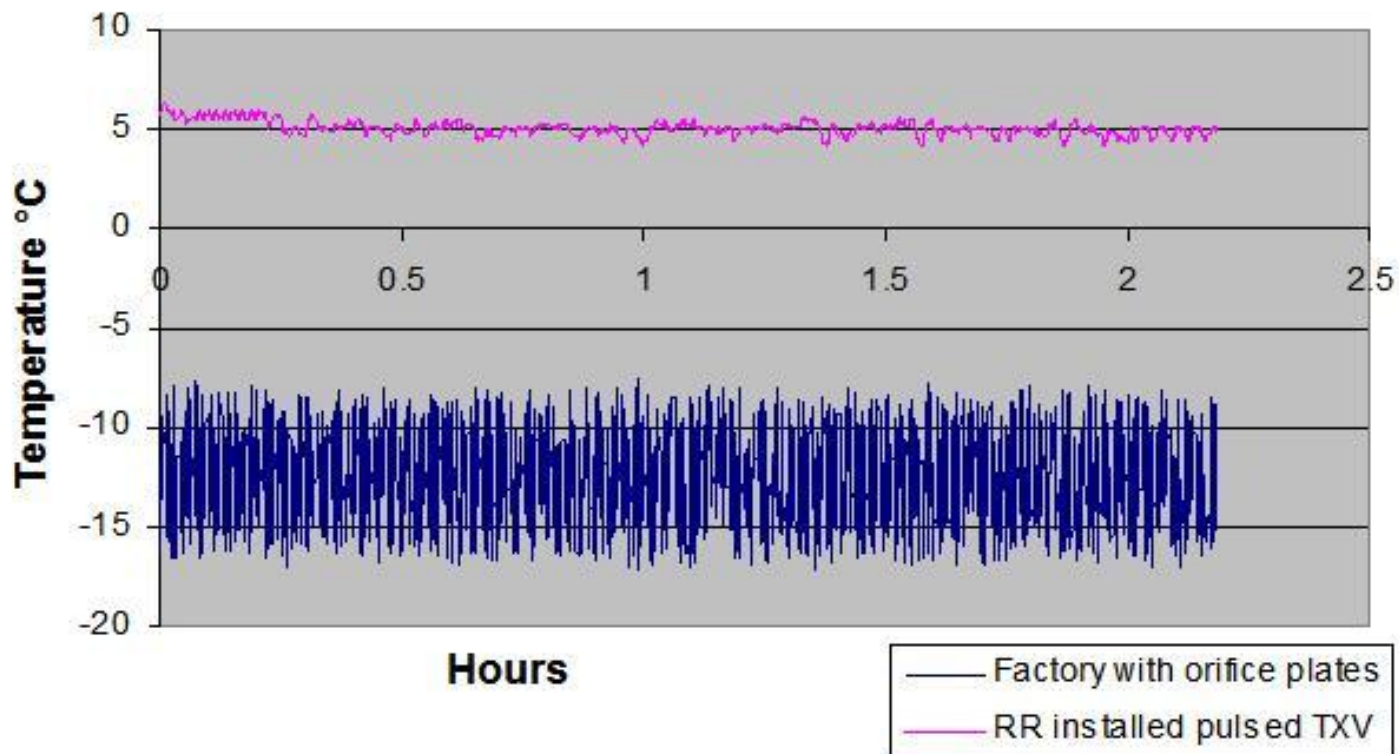
Superheat Test Results of Carrier 5 ton, R22, 50TM006 model

UNCLASSIFIED

POWER AND MOBILITY



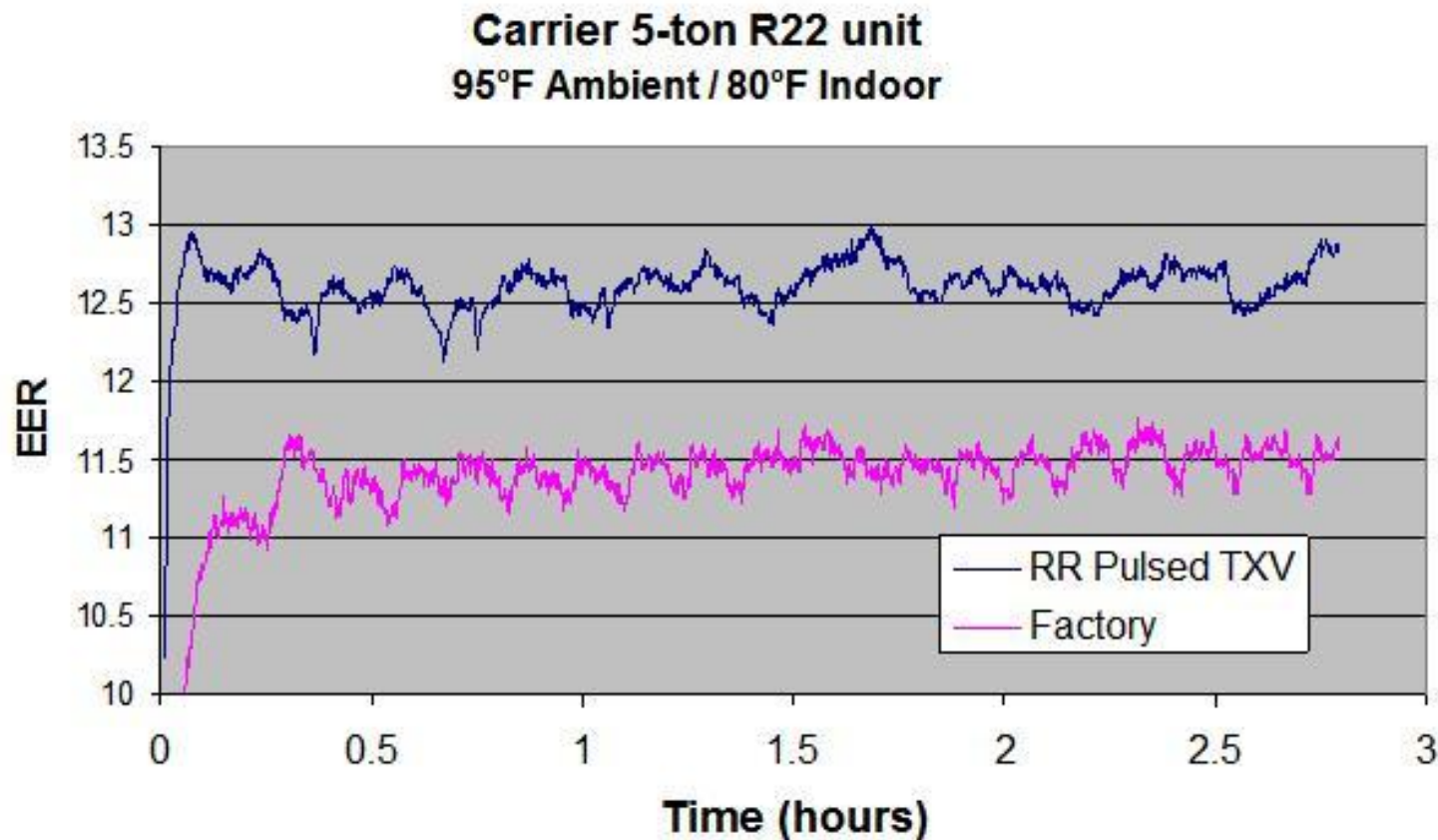
Superheat Comparison



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EER Test Results of Carrier 5 ton, R22, 50TM006 model (single speed)

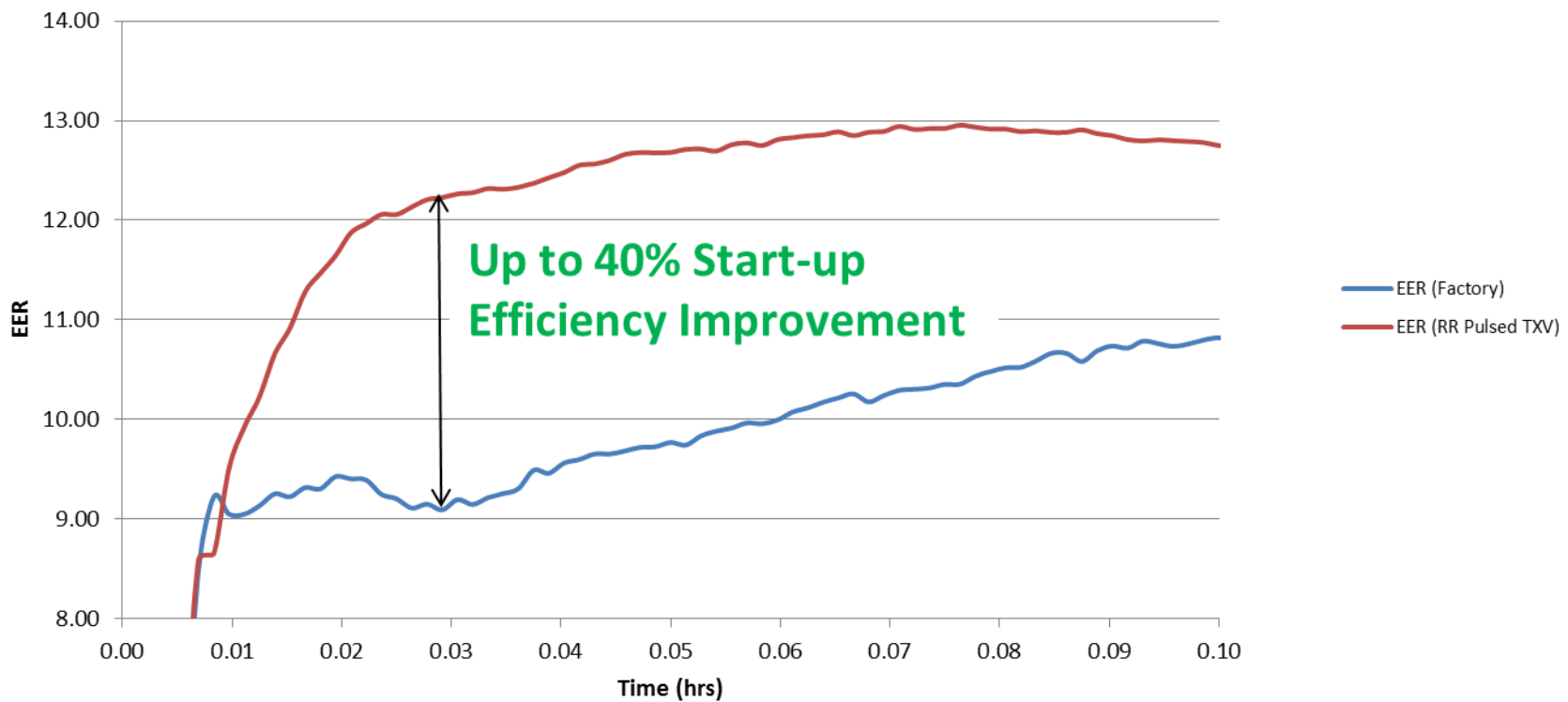
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Carrier 5-ton EER Start-up Comparison

POWER AND MOBILITY

Carrier 5-ton R22 Unit
95° F Ambient/ 80° F Indoor - Startup



Manufacturing /Reliability

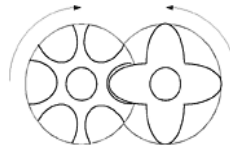
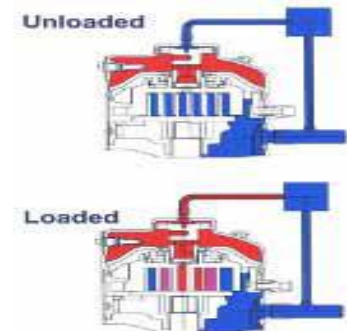
POWER AND MOBILITY

- Established TXV Reliability (on-going tests)
 - More than 500 million cycles (> 10 years) with TXVs installed on different systems
- Established First Cost Competitiveness
- Validated Manufacturing Process and QC

High Efficiency Scroll Compressor

POWER AND MOBILITY

- High efficiency due to near 100% volumetric efficiency
- Hermetic
- Requires no tip seals that wear out
- Light, compact and small footprint
- single speed to variable speed conversion for further enhanced efficiency



Variable Speed Compressor Test Stand

**POWER AND
MOBILITY**

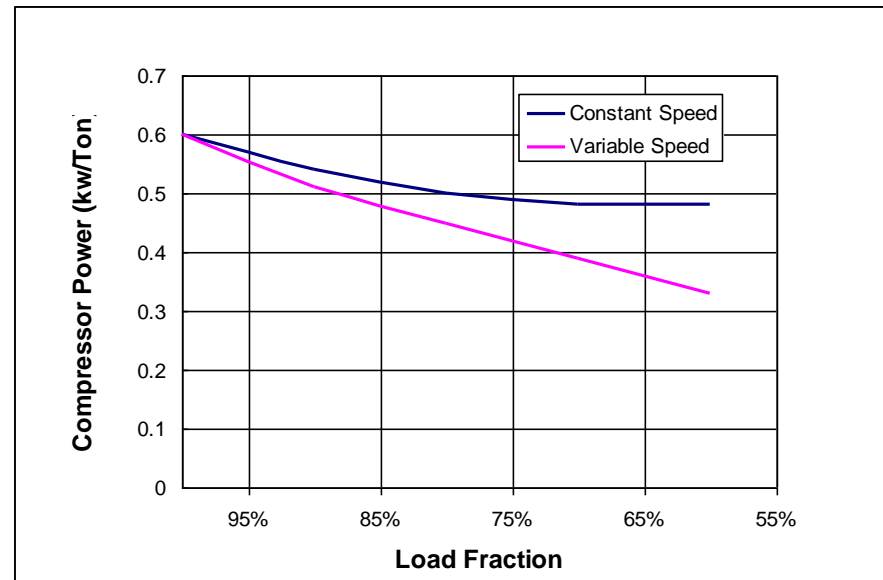
- Calorimetric test stand to measure capacity and power draw
- Evaporator air temperature is regulated using resistant heaters
- Refrigerant flow and air flows are measured
- Power is measured



Advantage of Variable Speed Control

POWER AND MOBILITY

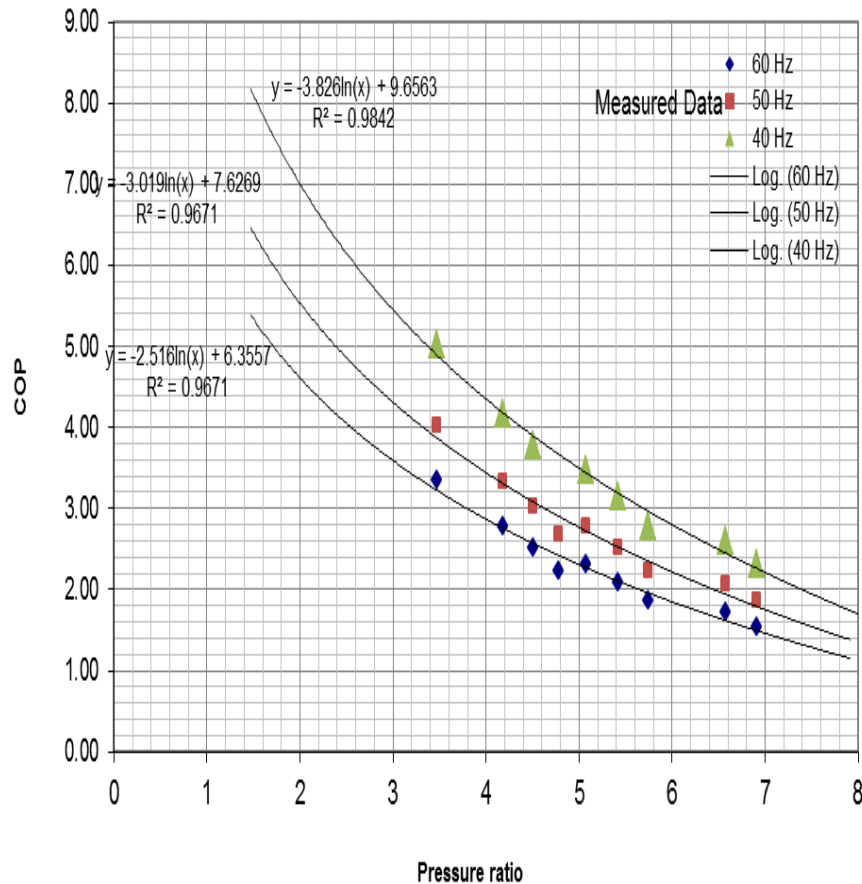
- Higher efficiency
- Matching loads
- Reduced fuel consumption
- Reduced wear
- Torque/frequency modulation considerations



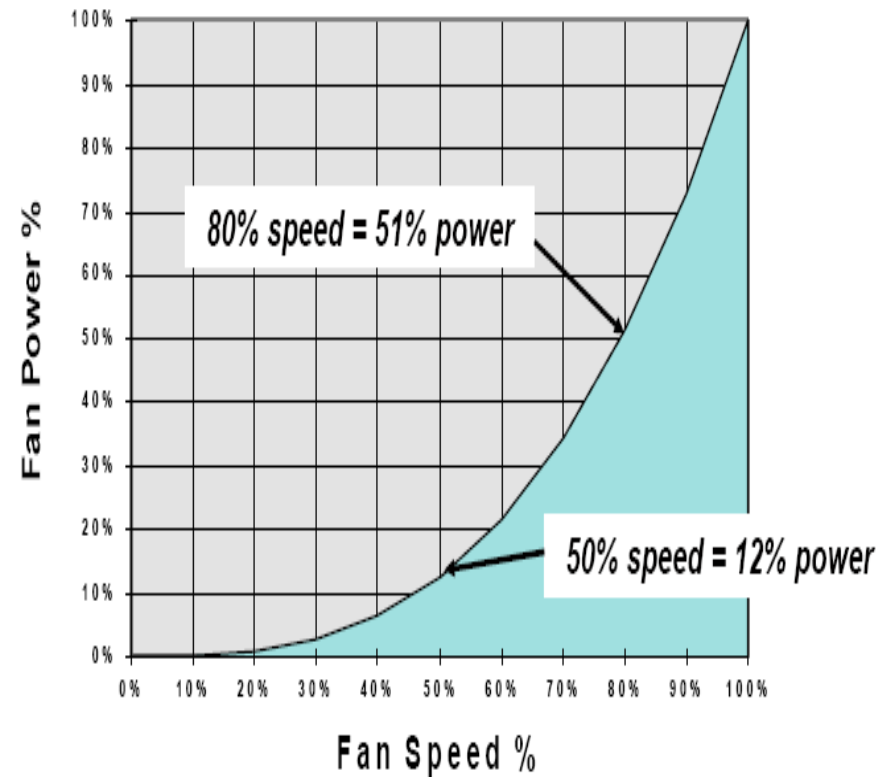
Test Results

POWER AND MOBILITY

COP with 3-phase hermetic compressor



Variable Speed Fan Control

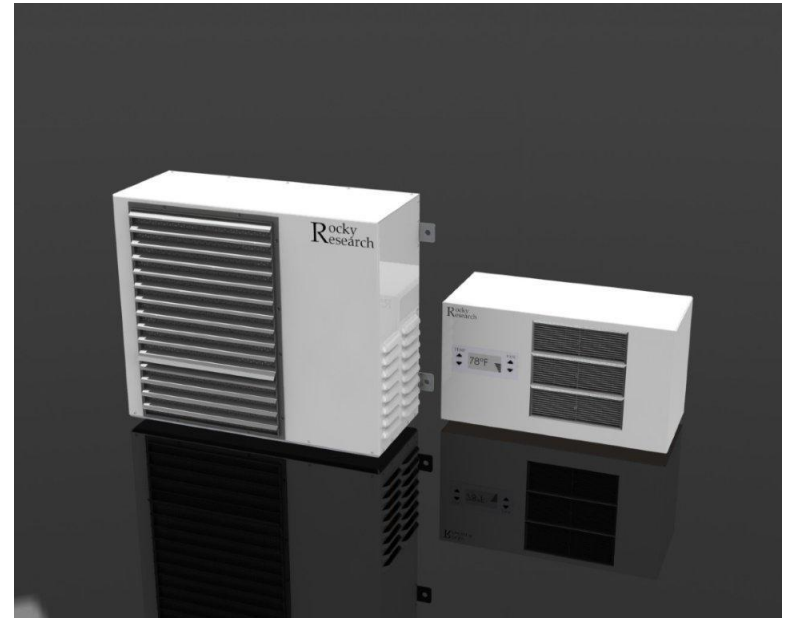


- Capacity varies directly with change in airflow
- Fan power varies with cube of change in airflow

Split System Proof of Concept

**POWER AND
MOBILITY**

- Variable speed
- Runs from either/or 120VAC or 12VDC
- Hermetic Scroll compressor (460-3phase)
- PTXV



System	Design Capacity in 125°F ambient (BTU/h)	Indoor unit volume (ft ³)	Outdoor unit volume (ft ³)	Mass (lbs)
vapor compression	6000	1.5	3.2	150
vapor compression	12000	1.5	4.1	175

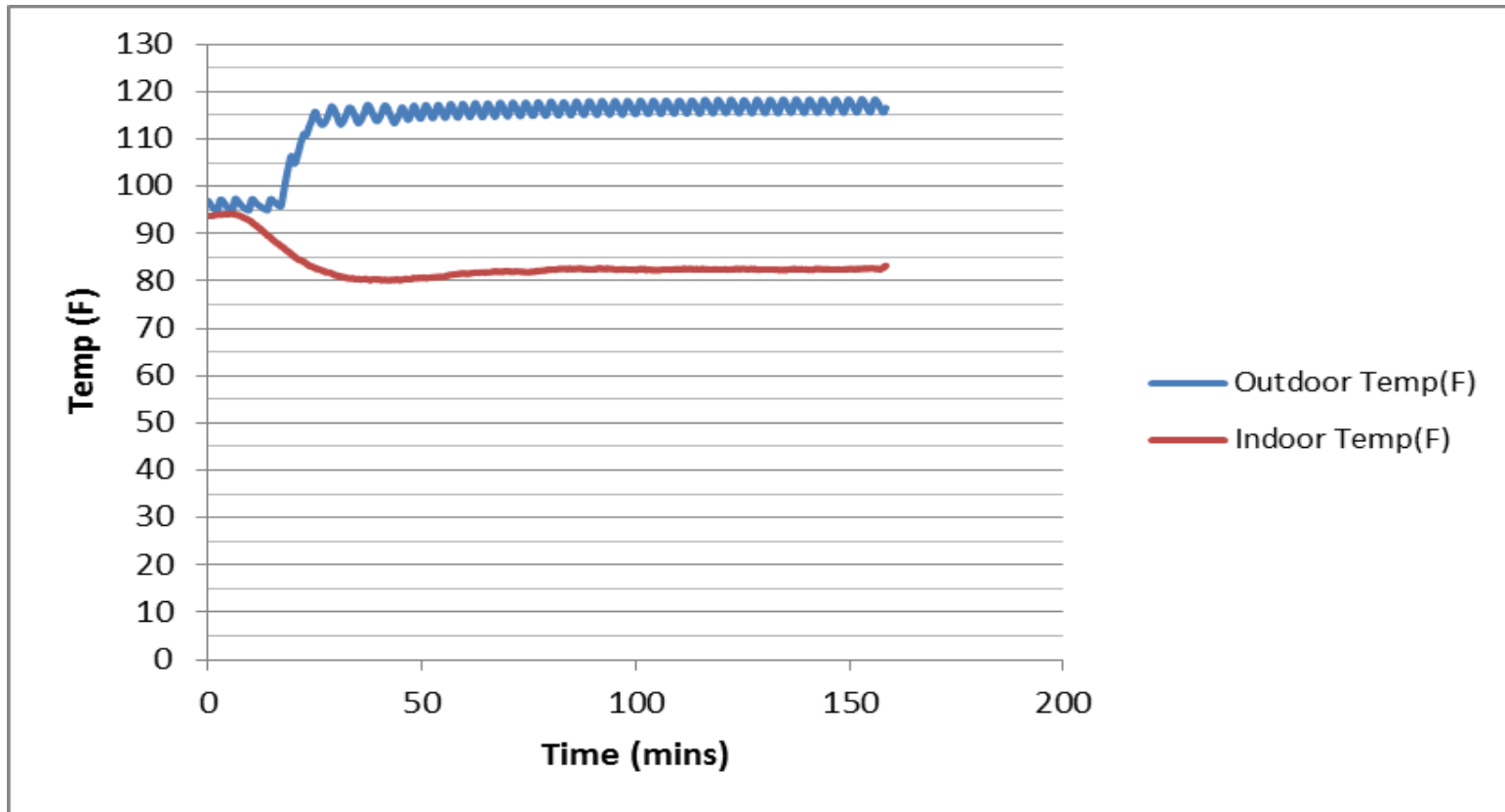
Test Chambers

POWER AND MOBILITY

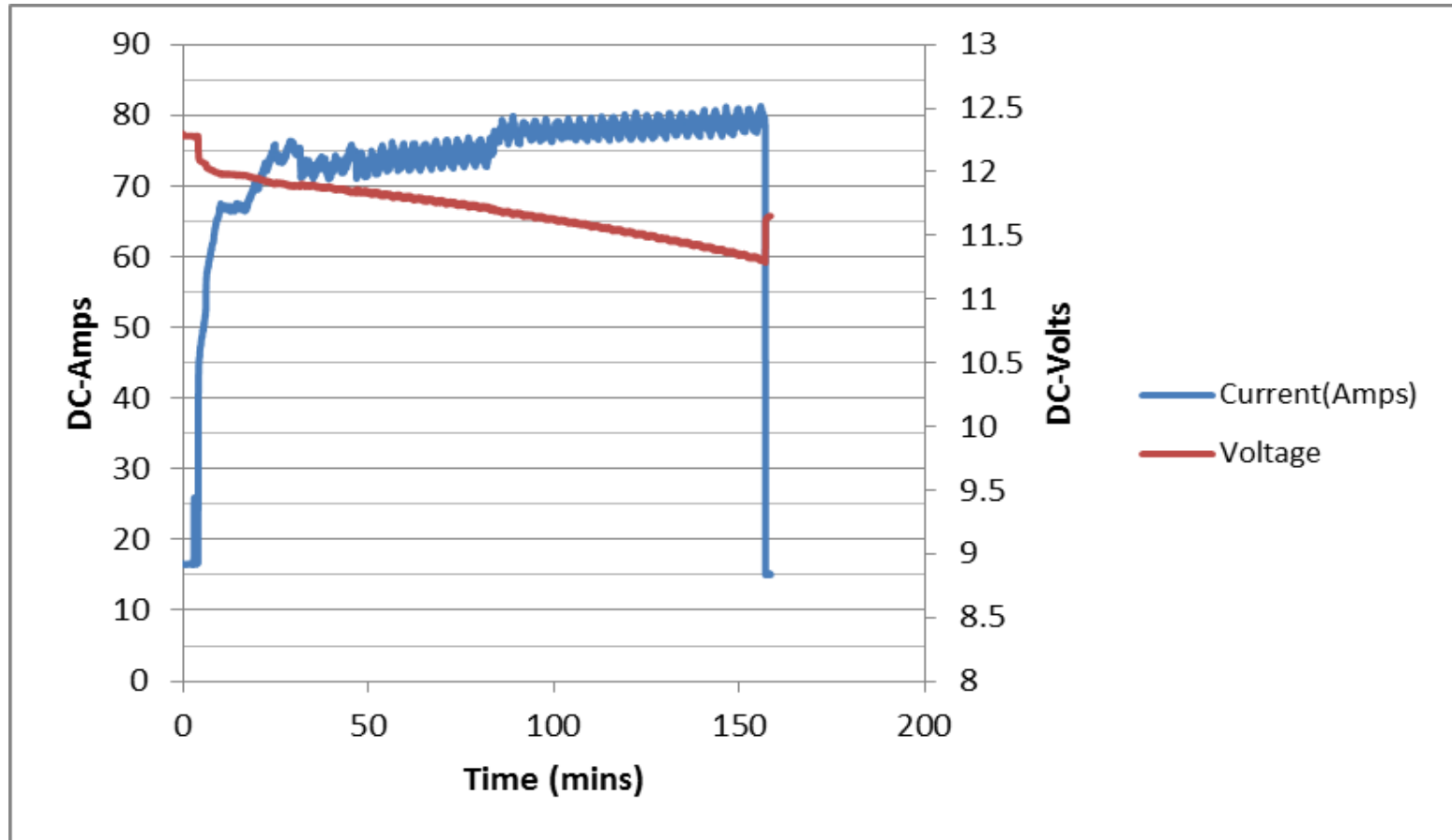
- One hydronic and one air-cooled/heated
- Indoor and outdoor section air temperature is regulated; heat added or removed is measured
- Refrigerant, air flow, and power are measured



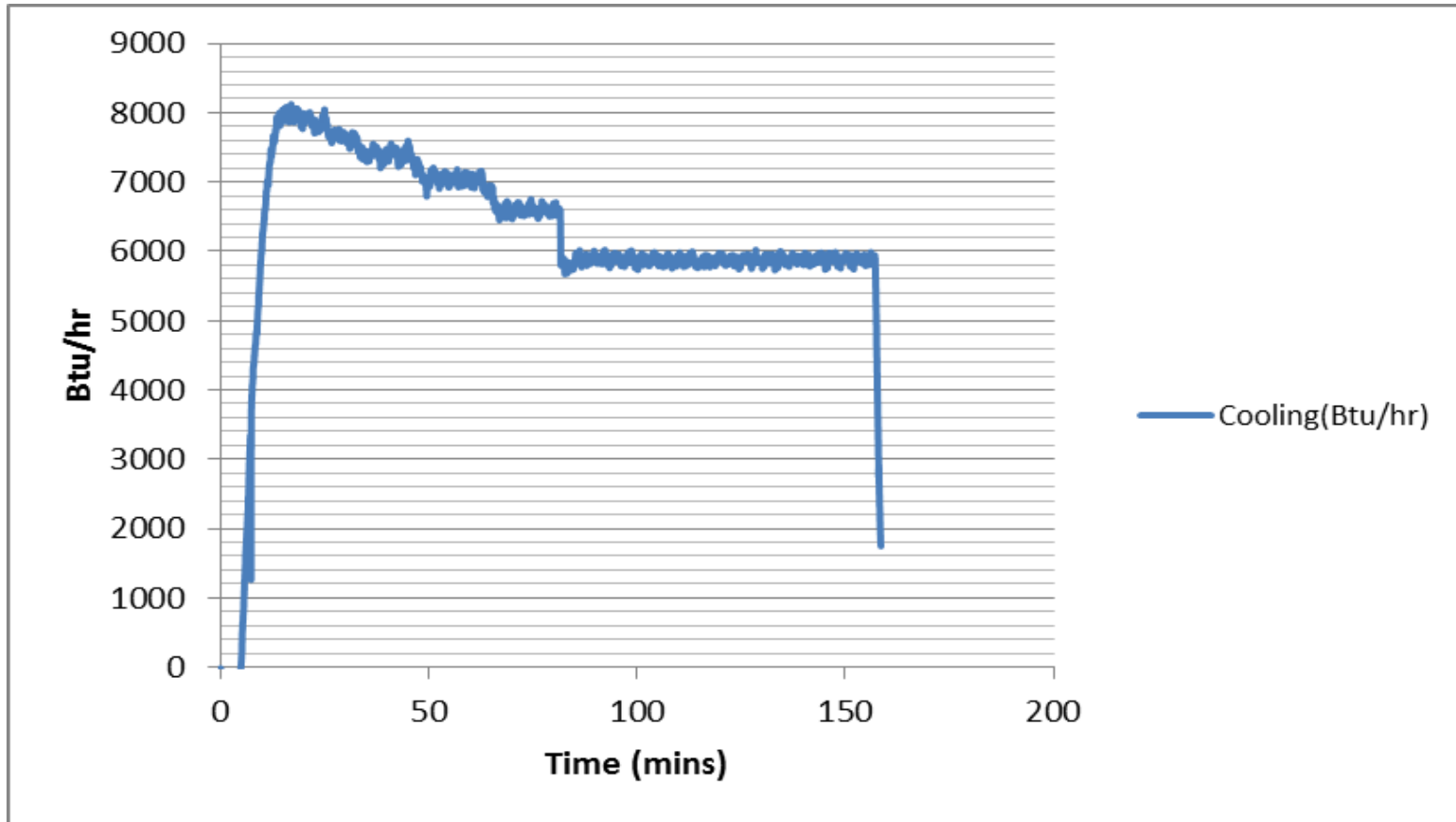
Test Chamber Temperatures

**POWER AND
MOBILITY**

Power Draw Measurements

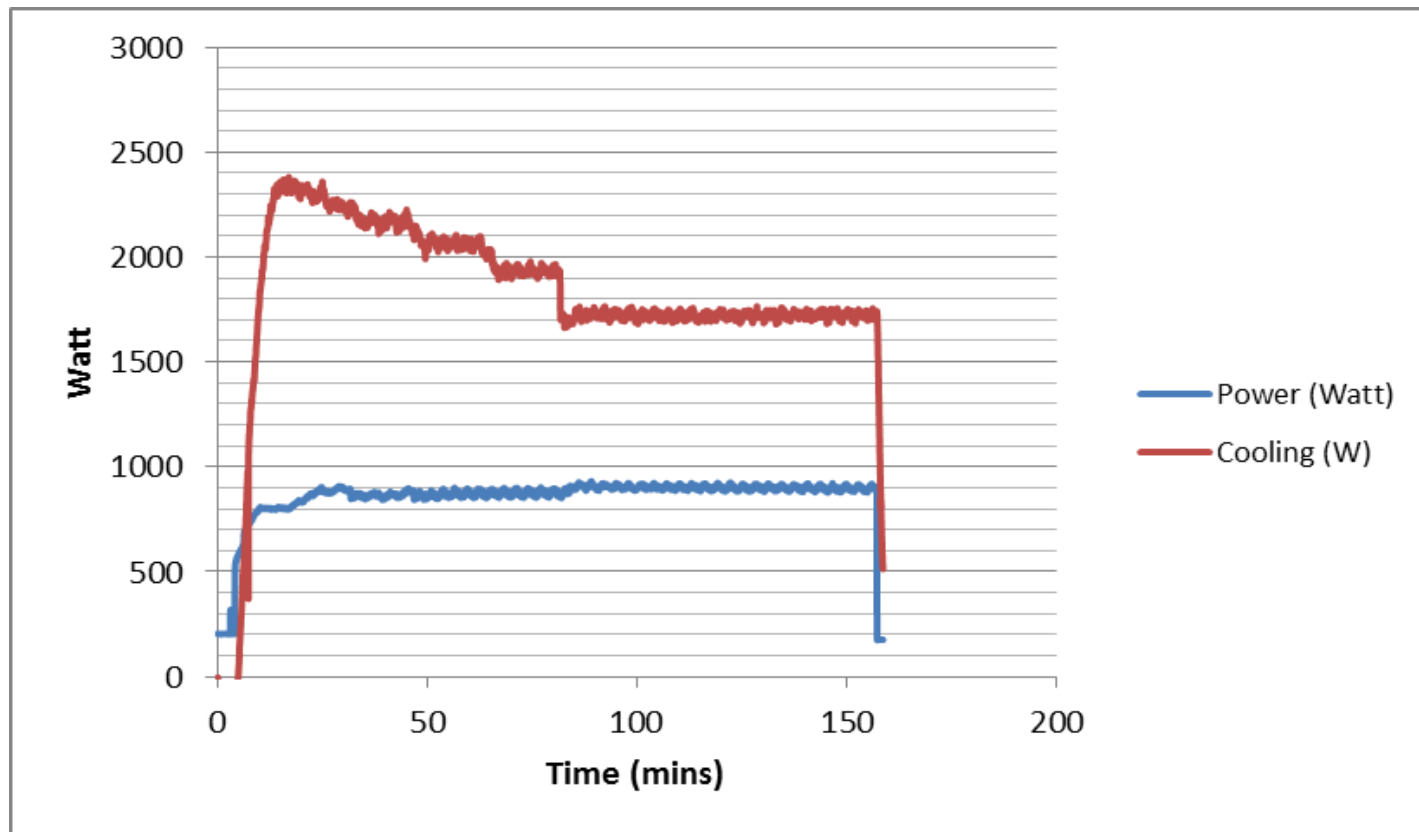
**POWER AND
MOBILITY**

Cooling Capacity Measurement

**POWER AND
MOBILITY**

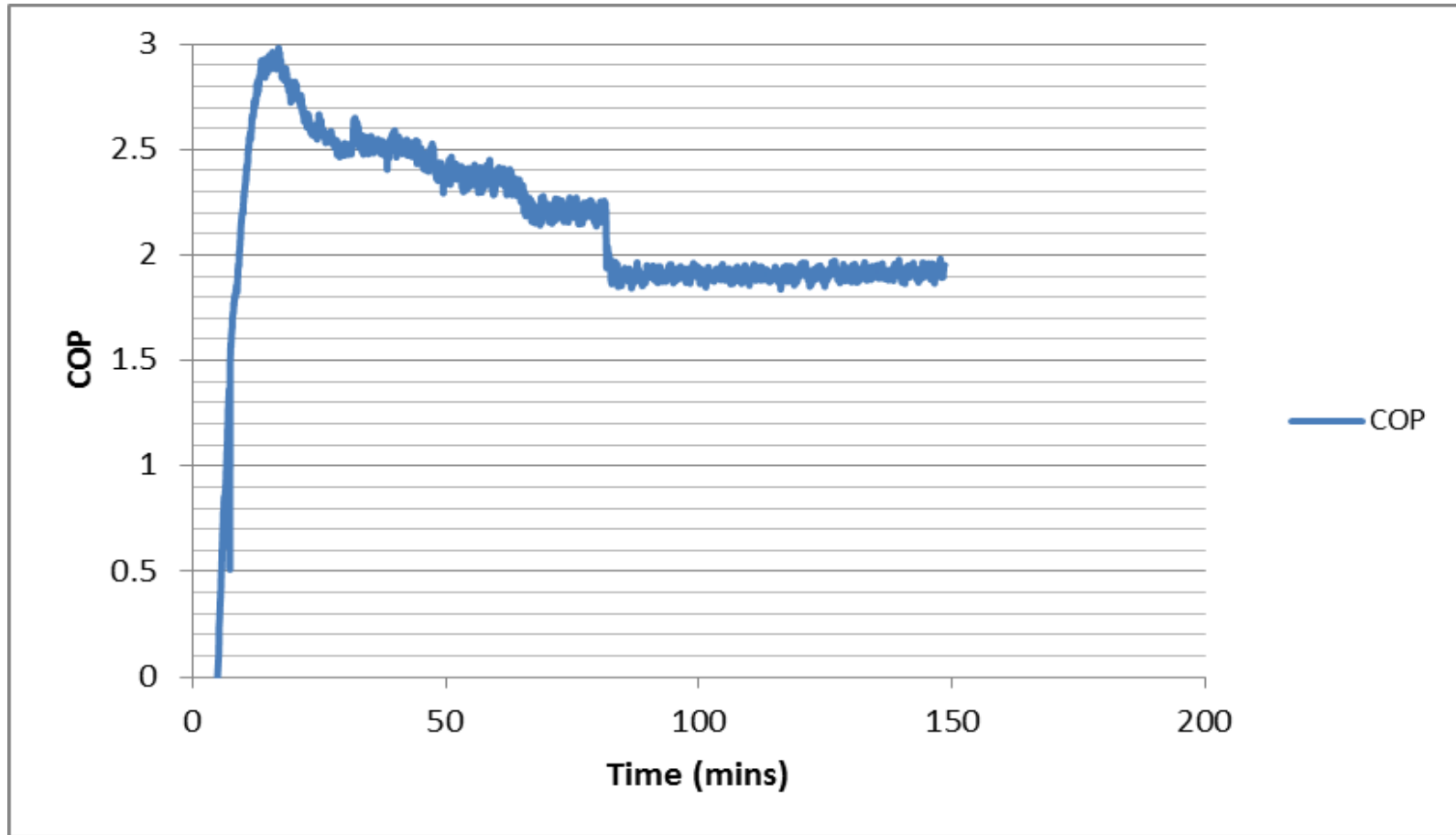
Power Draw and Capacity

POWER AND MOBILITY



Efficiency

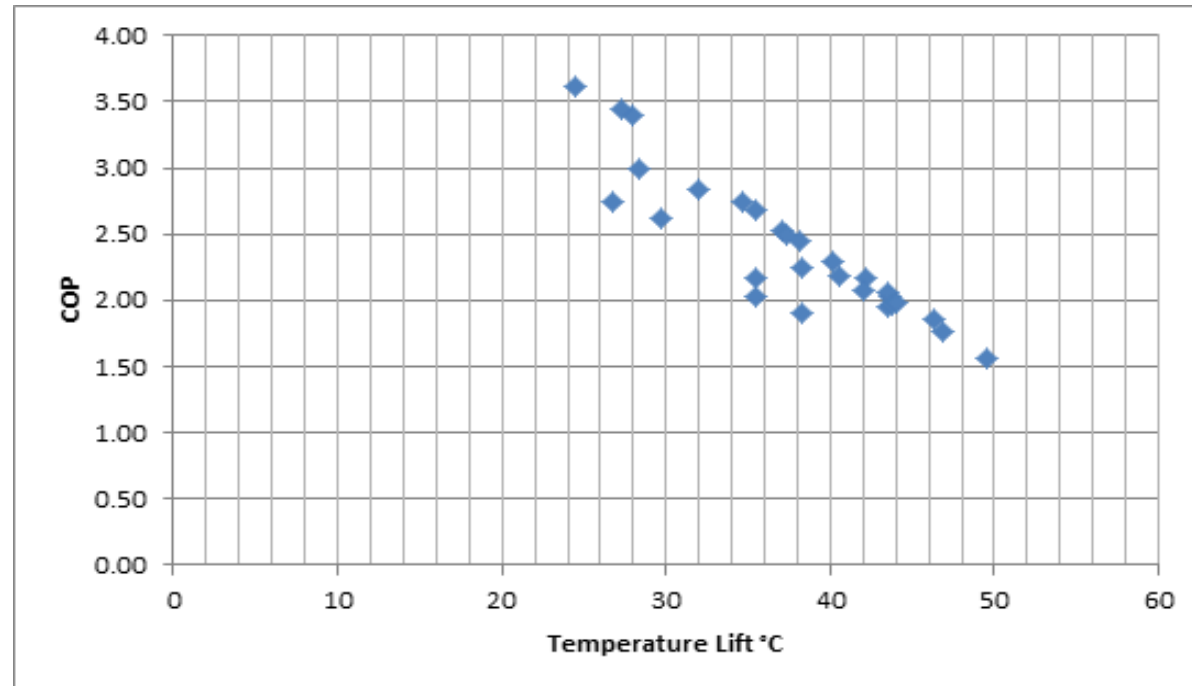
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Test Results at Other Conditions

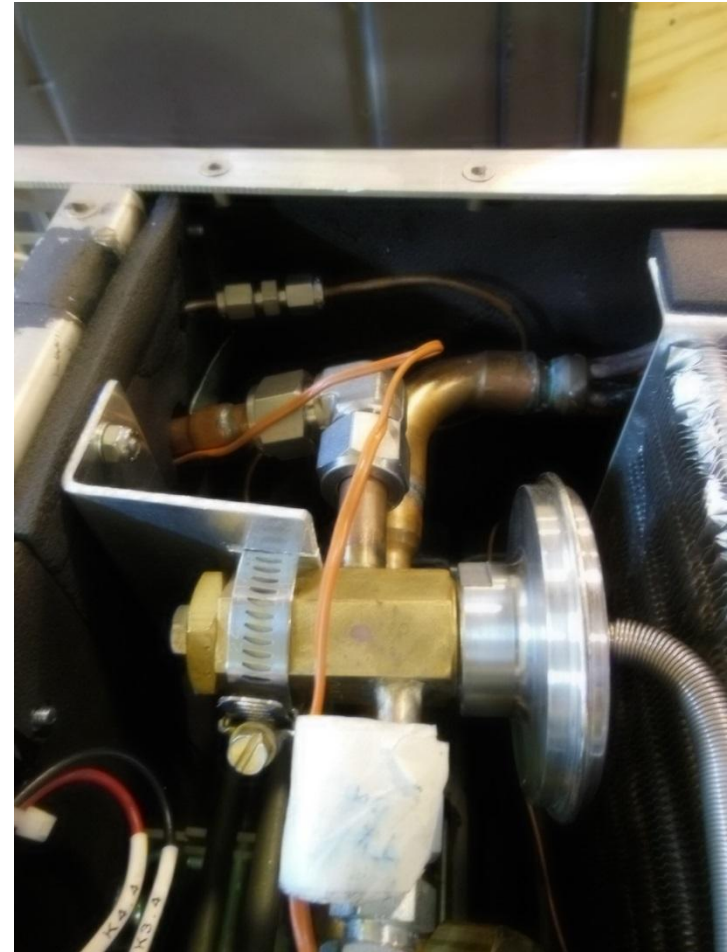
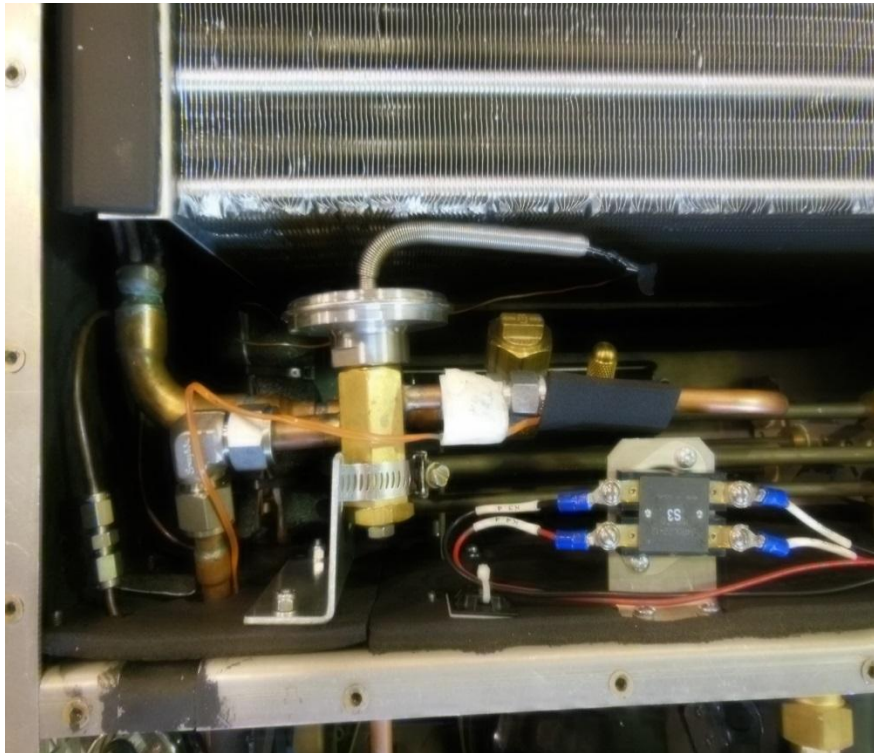
POWER AND MOBILITY

Condenser Temperature (C)	Evaporator Temperature (C)	Cooling (W)	Power In (W)	COP
36.2	0.8	976	449	2.17
39	0.7	1204	633	1.90
39.6	4.1	1312	647	2.03
43.7	14	1852	708	2.62
46.3	19.6	2039	742	2.75
43.9	19.4	1938	536	3.61
40.7	12.3	1514	505	3.00
46.4	18.5	2235	657	3.40
47.6	20.3	2320	674	3.44
43.55	-0.001	1556	795	1.96
38.8	0.5	1176	522	2.25
41.8	9.8	1640	578	2.84
44.7	-2.2	1531	870	1.76
50.1	6.4	2118	1041	2.03
55.4	13.3	2663	1226	2.17
55.2	11.7	2706	1311	2.06
50.1	3.8	2117	1141	1.86
47	-2.6	1578	1008	1.56
44	0.2	1575	799	1.97
47.9	7.8	2102	914	2.30
52.4	14.3	2575	1052	2.45
50.8	15.4	2481	925	2.68
47.5	10.4	2112	839	2.52
43.2	2.7	1592	731	2.18
41	-1	1413	680	2.08
45.8	8.5	1996	800	2.50
50.7	16	2542	925	2.75
55.5	11.4	2746	1383	1.98



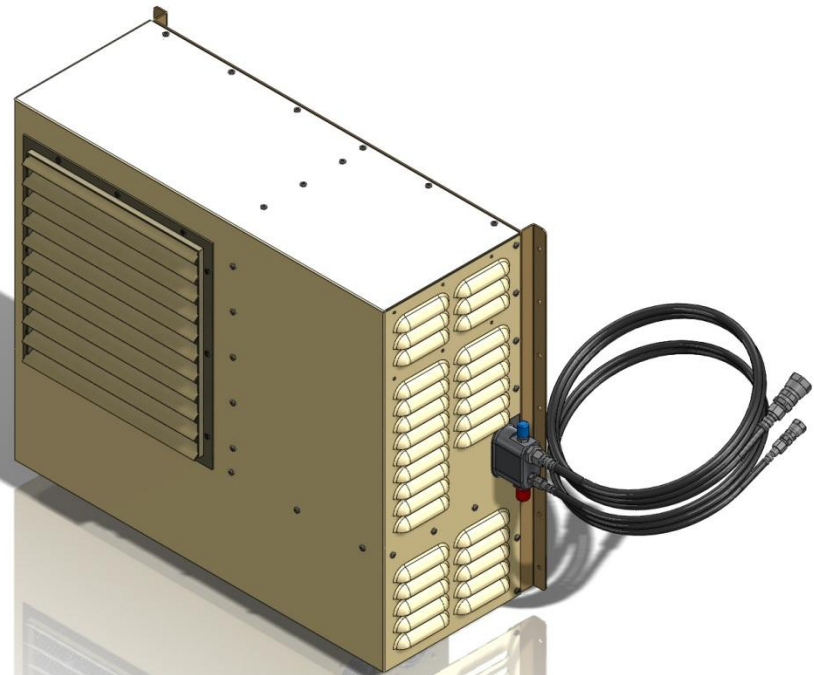
Back Up

PTXV

POWER AND
MOBILITY

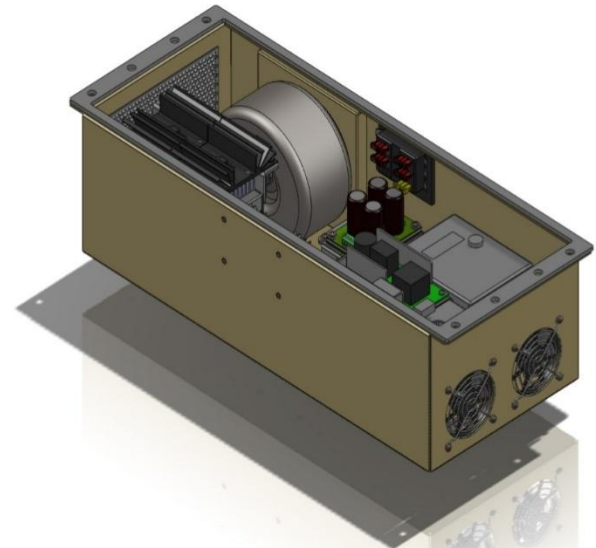
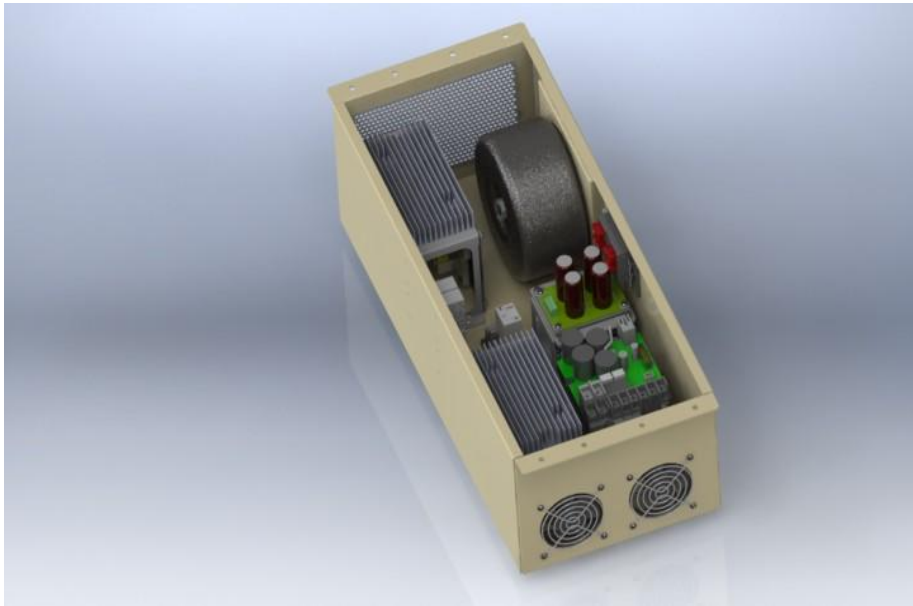
Condensing Section

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Power Electronics and Controls

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Indoor Section

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